An ethological experiment to improve airport security gate process reliability:

Understanding time perception and personal awareness of older adult travelers

Emmanuel Fragnière[1,2], Francesco Cimmino[1], Lionel Emery[1], Matthieu Héritier[1], Michael Kambly[1], Benjamin Nanchen[1], Randolf Ramseyer[1]

[1]University of Applied Sciences Western Switzerland, Sierre, Switzerland
[2]University of Bath, School of Management, Bath, UK
e-mail: emmanuel.fragniere@hevs.ch

Abstract

This research project aims to improve the management and reliability of airport security gate procedures by redesigning passenger queues based on human ethology methodologies. While queues have been studied from many angles, a scientific contribution based on a human ethology approach proposing regulation of queue dynamics to improve security effectiveness seems to be novel. Queueing behaviors, observed in previous fieldwork, led to the hypothesis that queue structuring can have a positive impact on wait time perception. This hypothesis was operationalized, according to ethology experiment design, through a passenger queue simulation. The data collected (n=140) confirmed the hypothesis. Average perceived time was lower for passengers who put items to be X-rayed on the belt in a specified order, along with higher personal awareness compared to the usual case where no order is imposed. Although this research is exploratory, we have been able to provide airport security management with some practical insights.

Keywords: airport security; human ethology; operations and management; security management; systems simulation

I. INTRODUCTION

Most of the experiences involving services consist of a system of queues connected to service points (counters, restaurant seating, etc.). Figure 1 shows a generic model of a system combining queue and service. We postulate that each type of service (e.g., a restaurant, an airport) requires a suitable queue design to maximize the salient attributes (major elements of value perceived by the customer or user) produced by the overall service.

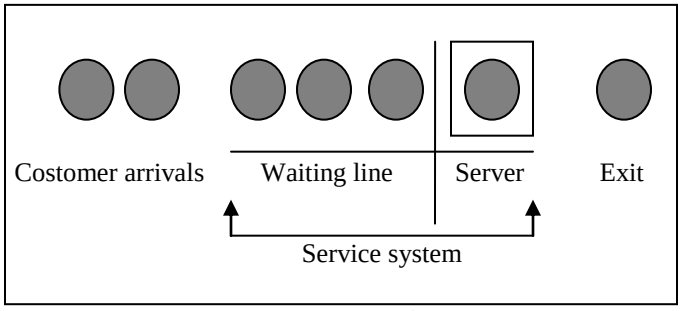

Figure 1. A generic representation of a service process.

At the beginning of the 20th century, Danish engineer Agner Krarup Erlang (1878-1929) developed queueing theory. He first applied his mathematical models to study the long queues of white-collar workers waiting their turn for the skyscraper lift to their office. Erlang was not only interested in quantitative models to evaluate waiting time and queue length but also in the perception of time spent in the queue (qualitative aspects, e.g. talking with colleagues or reading a newspaper may give the impression that the perceived waiting time is shorter than the actual waiting time). Unfortunately, today the two approaches (quantitative and qualitative) are too often treated separately.

On the one hand, quantitative approaches coupled with Monte Carlo simulation techniques now allow computers to calculate a range of indicators to manage a queue from an essentially operational point of view. For example, when wait times in the queue are considered too long, these models accurately assess the number of additional cashiers that need to be opened to return to a reasonable waiting time.

On the other hand, qualitative approaches allow us to grasp behavioral aspects of the queue. The most studied behaviors are a priori ("balking") and a posteriori ("reneging") impatience which leads to the abandonment of the queue if it seems too long and switching from one row to the other ("jockeying") to reduce the waiting time. For example, jockeying is a typical behavior of traditional queue configuration (multiple lines) and can create feelings of injustice. There are three main queue configurations based on the FIFO logic (first in/first out): multiple lines, serpentine lines, and a number ticketing system. Serpentines tend to eliminate the possibility of "jockeying". On the other hand, they are subject to more frequent abandonment behaviors when the queues are very long. Ticket-number queues reduce the risk related to the first two queue configurations. However, people tend to be less prepared and concentrated when the service begins. These aspects, as we will see in the literature review, have a significant impact on the overall client service satisfaction. This is why most scientific contributions related to the psychology of waiting lines concentrate on the importance of managing waiting lines to improve the overall service perception.

To the best of our knowledge, no service queue management research based on human ethology has been conducted on the possibility of getting a better engagement of customers waiting in queues to improve the effectiveness of security processes before entering a given facility.

In our past research, we have hitherto relied primarily on ethnomethodology (a qualitative approach to reveal the belief systems and social codes of an organization) to identify the main salient attributes (major elements of perceived value) of a service experience. However, ethnomethodology essentially reveals cultural traits and not necessarily behaviors that are typically human (i.e., innate).

To circumvent these drawbacks, we have recently employed research methodologies from human ethology. The founders of human ethology are Konrad Lorenz and Nikolaas Tinbergen. Ethology in a general manner is the study of the behavior of living things such as animals or humans in their "natural ecology". This discipline focuses on all the factors that induce certain behaviors, such as stimuli, innate, and learned. Two main methodologies are used: naturalistic observation and experimentation. The main tools are paper/pencil, picture, video, vocal recording. The main principle of ethology is to stay always at a descriptive level and to determine what is observed based on accounts. In the context of this research project, we adopt a quasi-experimental approach from human ethology to identify and understand more thoroughly the typical behaviors encountered in customer queues for security gate processing.

The general purpose of our study is to contribute to the improvement of service quality related to security management. We indeed believe that a proper customer engagement in security processing will improve their reliability. More precisely, the research question is “How can security gate queue design be improved based on a human ethology experiment so as to reduce customer frustration (i.e., the perceived waiting time)?”

The research project arises from a doctoral course that took place monthly during the period from January to July 2017. The main objective was to generate research hypotheses related to the ethology of customer queues in airports. All students (the authors of this paper) first presented scientific articles related to the field. Then based on a "LivingLab" (co-creation) approach, we developed together an experiment design that ultimately took place during the open days of the “Maison de l'Entrepreneuriat” on June 10, 2017, to offer visitors a simulation of airport queues. As the Maison de l’Entrepreneuriat used to be the headquarters of a famous Swiss aluminum company, most visitors at the open house happened to be ex-employees of it. This explains why we use the “older adult” age category in the title. Among these visitors, 140 took part in the experiment. The analysis of the data collected during this day confirmed our belief that properly structured queues would have a positive impact on perceived wait time. We could also conclude that proper queues can improve people’s awareness regarding security issues.

This paper is organized as follows. In Section II, we present a brief literature review of findings related to queue management and service satisfaction. In Section III, we describe the methods and the research design that we have implemented. In Section IV, we present the main results related to the experiment. In Section V, we conclude and indicate limitations of this research as well as further research directions.

II. LITERATURE REVIEW

Maister [1] was one of the first authors to discuss the psychology of queues. [2] emphasizes the importance of the control process and the announcement of wait times in order to maintain a sense of justice in the queue. [3] proposes a variety of stress-reduction mechanisms, such as providing clients with a wait time forecast, or offering clients fast-pass options. These practical suggestions can help managers reduce perceived waiting time, improve the customer's waiting experience, and generally improve the management of the queue. [4] demonstrates that some elements, such as music or queue structure, if properly managed, can have a positive impact on the perception of service expectation and satisfaction. The paper concludes with a comprehensive model including all the elements that the authors judge to affect the overall perception of service expectations. [5] shows that music or perfume can reduce the level of discomfort during a wait. The overall satisfaction level of the service therefore increases by the insertion of external stimuli during a queue. [6] highlights the importance of the relationship between the structure of the queue and the attitudes of clients. The authors question the perceived anxiety about whether the service will be delivered according to expectations and questions asked to users. [7] has developed an econometric model to explain wait in services. The authors show that some independent variables, such as the human factor and the visual elements, have a significant influence on the perception of clients’ expectations. [8] describes waiting as a psychological experience. The authors of this paper find that the traditional queue can produce a sense of injustice, even if from an objective point of view there is no inequality. [9] examines the difference between actual wait time and perceived wait time by the consumer, based on a case study. It emerges that there are different ways to reduce this difference and that depending on the emotional state of clients, the perceived waiting time may be longer or shorter. It is important to note that with the advent of new technologies and the internet, qualitative research has also focused on the perception of waiting in online services with, for example, Nah [10] who studied the wait time tolerated when consulting websites.

III. METHODOLOGY

Ethology is the study of the behavior of living beings (animals or humans) in their "natural ecology". This discipline is concerned with all the factors that induce a

certain behavior (stimuli, innate, acquired). Etymologically, ethology means the studies of manners. This term was coined in 1856 by the naturalist Geoffroy Saint-Hilaire. Unfortunately, human ethology is rarely used among management researchers. As Boris Cyrulnik pointed out in an article published in *l'express* on September 30, 1993 (www.lexpress.fr), "Man is a species that is part of the living world. It has inevitably behaviors that can be made observable thanks to hypotheses and methods derived from naturalistic observations." We are therefore convinced that human ethology approaches can help us better understand the queues of consumers and users. Human ethology can allow us to study innate human behaviors specific to queues, such as nervousness, impatience, or even boredom. All these emotional factors can alter or improve the perceptions of the client or user who is waiting for his/her turn to be served and in general for the overall service delivery.

A. The ethological experimental manipulation

Human ethology employs two main methods: the naturalistic observation and experimentation [11]. In this paper, we use the experimentation approach. In fact, the ethological experiment falls into the category of quasi-experiment. It means that we are not able to "control" all the variables present in the experiment as is the case with pure laboratory experiments. Human ethology can thus be classified as a qualitative methodology. So the goal is not to generalize findings but rather to discover new behavioral patterns. There is also no standardized approach. We can, however, describe it as a process containing these four main steps:

1. **Hypothesis formulation.** We start by formulating a hypothesis related to a given human behavior. This hypothesis is the answer to the stated research question.
2. **Hypothesis "operationalization".** We then "operationalize" the hypothesis through a simulation of the ecosystem under study to obtain a prediction of it.
3. **Data collection and analysis.** We collect and analyze the data of the experiment (in our case a simulation of passengers waiting at airport security gates).
4. **Conclusion.** We compare the statistical results to the prediction and also to other findings in the literature to assess the validity of the hypothesis.

Even if this kind of experiment cannot be considered to be a scientific approach, it has the advantage of replicating the original environment and its true dynamic. For instance, two persons in a row have no bag, no belt and no cell phone, so the time they will spend along the conveyer belt is minimal. Nevertheless, they will influence the rest of the waiting line. So, in reality, you never observe a group of people treated in a homogenous manner, a condition for the experimental manipulation.

B. A doctoral course as a LivingLab to design a research experiment.

By applying the LivingLab precepts (co-creation approach), we have during half a year (monthly sessions from January to July 2017) defined a design of an ethological experiment. A Living Lab can be seen as a "living laboratory", at the level of a region, in which users participate in the development of innovative products and services (co-creation). Its main goal is to understand the "insight," that is, the specific needs of the customers, so that new services emerge. It is also a test environment, open and benefiting from technological and methodological tools. It is, therefore, an ecosystem allowing a participatory process, using appropriate tools and methodologies [11].

From January to March, students had to read and present papers related to the research topic to develop a literature review. From April to June we developed the design of the experiment that took place on June 10. In July, we analyzed the findings and prepared this paper.

As presented in subsection A., we needed to start with a hypothesis. This was chosen keeping previous research [12] in mind and based on a naturalistic approach. The scope was to understand skiers' behaviors in cable car queues in order to improve their overall satisfaction, with 82 immersions episodes (i.e. participative observation) and 43 semi-directed interviews being conducted in the Swiss Alps. Several research hypotheses were proposed in that paper and we have retained the following one for this paper.

Hypothesis: A structured and fair waiting queue has a positive impact on the perception of wait time.

The goal was then to "operationalize" this hypothesis for a given context. So, we immediately chose the case of the airport waiting lines. This choice came quite naturally since our research institute (IEM) has signed a memorandum of understanding with Sion International Airport. Over the last two years, we have developed several applied research projects with them. The case of Sion is interesting since it used to be a military airport and now the goal is to transform it into a commercial one. So, all kinds of services have to be developed from scratch. For instance, last year, our institute organized the mandatory crash plane simulation on the tarmac required by the Federal Office of Civil Aviation (FOCA).

To pass the security gates in an airport, each passenger has to follow a stringent process. These are defined by international standards. Even if there are some variations from one airport to the other, this process aims at deterring any type of threats related to flight transportation. In a general manner, most airports adopt a multi-queue configuration. At the entrance of the service process, boarding pass and ID are checked. Then, each passenger must have a series of objects (belt, laptop, bag) X-rayed. Usually, no order is imposed about putting one's belongings on the conveyer belt. Thus, we can

consider that this part of the process is not structured. We decided to investigate more precisely this given part of the process. So, each student would come to the session with an idea of design experiment related to this part of the process and the class would perform informal re-enactments in the lab using props to test its relevancy. The goal was to create a simulation as realistic as possible to make participants feel as if they were in a real airport. The goal was to test alternatively two treatments for comparison purposes. The first one would mimic the conventional approach that is with no order being imposed for putting the different belongings on the conveyer belt to be X-rayed. The second treatment was to include a division of tasks in the process including a sequence imposed on passengers for putting their belongings on the conveyer belt. Our prediction was that the second treatment would have a positive impact on the wait time perception of passengers since they would be engaged in a process that required them to accomplish precise tasks.

A. Experiment

The experiment took place on June 10, 2017 at the Foyer in Sierre, in our laboratories located in the basement of the building, from 14:30 to 18:00. This experiment was part of the Foyer open days. The Foyer used to be the headquarters of an important Swiss aluminum company. The building has been recently completely refitted and now hosts the Institute of Entrepreneurship and Management (IEM). The goal of the Foyer open days was to show the public how this industrial heritage had been transformed into a research center for entrepreneurship. The press release invited the visitors of "Le Foyer" open days to take part in a queueing experience.

Visitors arriving (Figure 2, point 1) at the front entrance (through the garden) of our fictitious airport were greeted by a steward (one of our team) explaining the activity. Each visitor would receive a voucher for a drink in the form of a boarding pass if they agreed to take part in the experiment. Once a group was constituted, the steward would write on a list the time of entrance with the boarding pass number of each group member.

When the group was inside, it was invited to listen to a historian for a short explanation about the old bowling game that used to be played in this hall (Figure 2, point 2). Each visitor was free whenever he/she wanted to go to the control desk (Figure 2, point 3). At the control desk, there was an officer (one of our team) who was checking the boarding pass of each visitor. The officer would write down the boarding pass number on a list along with the time. The visitors would then queue in the serpentine line.

Once at the end of the serpentine (Figure 2, point 4), each visitor went to line A or B as indicated on his/her boarding pass. At each desk (A and B), there was an agent (one of our team) helping the visitor and providing him/her with instructions (see Figure 3). There was also a poster showing which items were to be put in the plastic tray:

- bag and jacket
- cell phone
- watch
- belt
- wallet
- coins

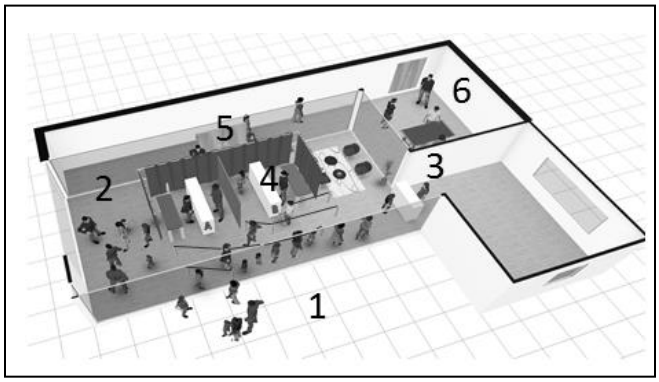

Figure 2. Layout of the experiment

There were two settings for the experiment:

1. **Unstructured protocol (UP).** The poster indicates no order in which to put the items in the tray.
2. **Structured protocol (SP).** The poster indicated the order in which to put the items in the tray. To make it easier for the visitor, the large plastic tray in this setting had 3 smaller boxes inside.

Alternatively (every 20 to 30 visitors), both A and B lines would implement at the same time either the unstructured protocol (UP) or the structured protocol (SP).

Once every item was in the tray, the visitor would be ready to pass through the security gate. A controller (again, one of our team) would activate a green light, and indicate to the visitor that he/she could pass. Once on the other side, concealed by dark curtains, the participant could take back his/her things (Figure 2, point 5). This was the end of the process. Another agent (one of our team) would wait for the visitor to put on all of his/her belongings. The agent would write on a list the time and the boarding number. The agent would then give to the visitor a one-page questionnaire (with his/her boarding pass number written on it) to complete outside the experiment area (Figure 2, point 6).

Finally, two supervisors (team members) assisted the visitors in filling out their questionnaires. To thank the visitors who had filled out their questionnaires, the supervisors gave them a voucher for food which again looked like like a boarding pass. A total of 140 visitors took part in the experiment.

Figure 3. A visitor begins putting his belongings in the tray.

IV. RESULTS

A. Population sample characteristics

We had 140 visitors take part in the experiment (133 valid questionnaires). The average age of the sample was 54. Roughly 2/3 of the visitors fell into the older adult category (55 years+) because most visitors were former employees of the aluminum company. Due to the importance of this category, we have included it in the title of the paper. The average number of flights taken per year was 1.86. The percentage of men was 48% (n=64) and the percentage of women was 52% (n=69). The percentage of visitors in phase II having experienced the unstructured protocol (UP) for the security check was 60% (n=84). The percentage of visitors in phase II having experienced the structured protocol (SP) was 40% (n=56). The difference between the two is due to the fact that we started with the first protocol and conducted four runs. We conducted three runs for the second protocol. We finally stopped the experiment around 19:00.

B. Actual and perceived time

In the questionnaire, the following two questions were asked:

- In your opinion, how many minutes passed from when you entered the "hall" until the "boarding pass control"? (Phase I)
- In your opinion, how many minutes passed from the "boarding pass control" to the "questionnaire distribution"? (Phase II)

We discovered that the average actual time for Phase I was 4.5 minutes and the average perceived time for Phase I was 5.9. In this case, our sample of visitors overestimated their actual waiting time by 31%.

We found that the average actual time for Phase II was 2.6 minutes and the average perceived time for Phase II was 3.2. In this case our sample of visitors overestimated their actual waiting times by 23%.

These first results are fully in line with the scientific literature. Indeed, most studies report a positive overestimation of the perceived time compared to the actual time. For instance, [13] shows a difference of 21% (actual wait time = 4.2 minutes and perceived wait time = 5.1 minutes) in the banking sector. [14] shows a difference of 37% (actual wait time = 2.8 minutes and perceived wait time = 3.8 minutes) in the English retail sector.

Regarding the two protocols, the actual wait time in Phase II was 2.6 minutes, which means that on average this part of the process required about the same amount of time to be completed. On the other hand, the perceived wait times on average for the unstructured Protocol (UP) and for the structured Protocol (SP) were 3.4 minutes and 2.7 minutes, respectively. We see that when visitors are instructed to put their belongings in the tray following a given order, their time perception is lower and closer to the actual wait time. We could explain this phenomenon by the fact that they have to concentrate more on what they are doing.

C. Security, apprehension and intrusiveness

In the questionnaire, we also asked participants to judge these three statements:

1. In general, during a security check at the airport, I feel safe.
2. In general, during a security check at the airport, I have some apprehension.
3. In general, I find that the security controls at the airport are intrusive.

The visitors had to answer this question using this Likert scale: (1) strongly agree, (2) agree, (3) neither agree nor disagree, (4) disagree, (5) strongly disagree.

It is interesting to note that if we compare the answers given by visitors who had experienced the unstructured protocol (UP) and visitors that had experienced the structured protocol (SP), the average point of the 5-point Likert scale for each of the 3 answers indicate a similar trend: all answers tend to be translated toward the right-hand side of the scale (i.e., the disagree direction) for the structured protocol compared to the unstructured protocol (1. "Feel safe", UP: 1.55 and SP: 1.70; 2. "Apprehension", UP: 3.04 and SP: 3.43; 3. "Intrusive", UP: 2.95 and SP: 3.23). We explain this phenomenon by suggesting that the structured protocol raised the awareness of the visitor and he/she was thus providing a more precise answer regarding his/her own perception.

V. CONCLUSION

The security gate procedure is an essential component of airports today designed to deter any kind of threat related to air transportation. Each year security systems gain in terms of reliability thanks to new technologies and know-how. There is, however, untapped potential to improve its

reliability. Indeed, in service production, the client is considered as a co-producer [15]. So, if the engagement of the client in a service process is truly important, we can expect a higher service level in terms of effectiveness but also in terms of satisfaction. To address this issue at the waiting line phase of the security gate process, we have developed an experimental approach based on human ethology and designed to study typical passenger behavior. The ethological experiment started from a cause and effect hypothesis describing a behavioral pattern. This hypothesis is usually generated from naturalistic observation. Then, the hypothesis was "operationalized" through a simulation to obtain a prediction of it. If the prediction corresponds to the hypothesis, then it is validated.

The hypothesis that we have retained is that when people are waiting in a structured queue, it should have a positive impact on their wait time perception. In our experiment, we considered two protocols for passengers to put items on the conveyer belt to be X-rayed. Practically, in the first protocol people could put the given items in any order (i.e., the actual situation in most airports). In the second protocol, people had, based on the same list of given items, to follow a strict order. The results we have obtained is that for the second protocol the average perceived wait time was lower compared to the average perceived wait time of the first protocol. Moreover, it also seems that the degree of awareness of people regarding security issues is higher in the context of the second protocol than in the context of the first one. This would mean that if passengers were more involved in the security gate process through the waiting line being given more structure, we could expect an improved reliability.

It should be emphasized, however, that the ethology experiment used here cannot be considered as an experimental manipulation enabling the researcher to draw generalized results. In fact, the ethnographic experiment is rather a quasi-experimental manipulation. Indeed, in the context of social experimentation, it is difficult to respect all the rules of pure scientific experimentation (such as the control of all variables and the constitution of samples on a random basis). So, our effort should be considered more as exploratory research than a scientific project. Nevertheless, results should be seen rather as a way to discover new behavioral patterns in the context of airport customer queues. Although human ethology can be classified as a qualitative methodology, we are convinced that such findings are sufficiently practical to provide security and risk managers with relevant insights.

In the future, we intend to explore other aspects of queue behaviors related to security management, such as mood contagion, the herd instinct, the outbreak of violence, and mimicry phenomena.

REFERENCES

[1] D. Maister, The Psychology of Waiting Lines, in The Service encounter: managing employee/customer interaction in service businesses, J.A. Czepiel, M. R. Solomon, and C. F. Surprenant, Eds. MA: D. C. Heath and Company, Lexington Books, pp. 113–123, 1985.

[2] S. Naumann and J. Miles, "Managing waiting patients' perceptions: The role of process control", Journal of Management in Medicine, vol. 15, no. 5, 376–386, 2001.

[3] W. Nie, "Waiting: integrating social and psychological perspectives in operations management", Omega: The International Journal of Management Science, vol. 28, no. 6, pp. 611–629, 2000.

[4] J. Baker and M. Cameron, "The Effects of the Service Environment on Affect and Consumer Perception of Waiting Time: An Integrative Review and Research Propositions", Journal of the Academy of Marketing Science, vol. 24, no. 4, pp. 338–349, 1996.

[5] J. McDonnell, "Music, scent and time preferences for waiting lines", International Journal of Bank Marketing, vol. 25, no. 4, pp. 223–237, 2007.

[6] A. Rafaeli, G. Barron, and K. Haber, "The effects of queue structure on attitudes", Journal of Service Research, vol. 5, no. 2, pp. 125–139, 2002.

[7] C. Choongbeom and S. Atul, "Assessing the Relationship Between Waiting Services and Customer Satisfaction in Family Restaurants", Journal of Quality Assurance in Hospitality and Tourism, vol. 13, no 1, pp. 24–36, 2012.

[8] A.C.R. Van Riel, J. Semeijn, D. Ribbink, and Y. Bomert-Peters, "Waiting for service at the checkout: Negative emotional responses, store image and overall satisfaction", Journal of Service Management, vol. 23, no. 2, pp. 144–169, 2012.

[9] A. Whiting and N. Donthu, "Closing the gap between perceived and actual waiting times in a call center: results from a field study", Journal of Services Marketing, vol. 23, no. 5, pp. 279–288, 2009.

[10] F. Nah, "A study on tolerable waiting time: how long are Web users willing to wait?", Behaviour and Information Technology, vol. 23, no. 3, pp. 153–163, 2004.

[11] I. Eibl-Eiblsfeldt, Human ethology. NY: Aldine de Gruyter, 1989.

[12] E. Fragnière., V. Gaillet, B. Nanchen, and R. Ramseyer, "Using Ethological Approaches to Understand Skiers' Behavior in Cable Cars Queues in Order to Improve Overall Satisfaction: An Empirical Study Conducted in the Swiss Alps", LNBIP book series, Springer, Vol. 279, 2017, pp. 421–430.

[13] K.L. Katz, B.M. Larson, and R.C. Larson, "Prescription for Waiting in-Line Blues: Entertain, Enlighten, and Engage", Sloan Management Review, vol. 32, no.2, pp. 44–53, 1991.

[14] P. Jones and E. Peppiatt, "Managing perceptions of waiting times in service queues", International Journal of Service Industry Management, vol. 7, no.5, pp. 47–61, 1996.

[15] S. L., Vargo, P. P. Maglio, and M. A. Akaka, "On value and value co-creation: a service systems and service logic perspective", European Management Journal, vol. 26, no. 3, pp. 145–152, 2008.